Designing technologies for museums: accessibility and participation issues

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Abstract

Purpose – *This paper aims to report the findings of a systematized literature review focusing on participatory research and accessibly in the context of assistive technologies, developed for use within museums by people with sensory impairments or a learning disability. The extent and nature of participatory research that occurs within the creation of technologies to facilitate accessible museum experiences is uncertain, and this is therefore a focus of this paper.*

Design/methodology/approach – *This paper is a systematized literature review and subsequent thematic analysis.*

Findings – *A screening of 294 research papers produced 8 papers for analysis in detail. A thematic analysis identified that the concept of accessibly has nuanced meanings, underpinned by social values; the attractiveness of a technology is important in supporting real-life usability; and that the conceptualization of participation should extend beyond the end users.*

Social implications – *The argument is made that increasing the participation of people with sensory impairments and learning disabilities in the research process will benefit the design of technologies that facilitate accessibility for these groups.*

Originality/value – *An original notion of participation has emerged from this review. It includes the participation and goals of disabled people but has expanded the concept to encompass museum personnel and indeed the physical and social spaces of the museums and heritage sites themselves. This constructs a broad of participation, with different aspects being reflected across the review's research papers.*

Keywords *Participatory research, Assistive technologies, Sensory impairments, Learning difficulties, Accessibility, Museums*

Paper type *Literature review*

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Introduction

There has been an increasing recognition of the importance of cultural and heritage sites, such as museums, within people's life experiences. More recently this importance has been acknowledged and explicitly foregrounded for people who may require support to access and enjoy these sites. This includes people with learning disabilities (Seale and Chadwick, 2017) and those with a visual impairment (Reichinger *et al.*, 2016) or hearing impairment (Milicchio and Prosperi, 2016). In relation to people with learning disabilities, identified two potential approaches that might facilitate their access (Seale and Chadwick, 2017):

1. the development and employment of technologies; and
2. the implementation of inclusive or participatory approaches to research and design (Seale and Chadwick, 2017, p. 10).

These two broad approaches have face validity for a broader group of potential museum users. They can be seen as ways to facilitate access for "casual visitors who are visually impaired, deaf or who have learning disabilities" (Partarakis *et al.*, 2016, p. 237). The importance of this issue is reflected in The UN Convention on the Rights of Persons with

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Disabilities (United Nations, 2006), which argues that assistive and digital technologies have a central role in the lives of disabled people and therefore requires that national government address the assistive technology needs of their citizens (Borg *et al.*, 2011). In this context, the term "participatory research" refers to the notion of "end users" being involved in the development or implementation of technologies within museums and directs researchers to support such engagement (Wright *et al.*, 2011). Participatory involvement is relatively common within educational research (Abbott *et al.*, 2011), where it can include "end users" being active central research team members who are involved in all stages of the research process. The nature of participatory research, and the extent to which it occurs, within the creation of technologies to facilitate accessible museum experiences is uncertain, and this is therefore a focus of this paper.

Review methodology

A variety of methods are used to review and extract data from bodies of research literature. These range from critical narrative reviews, which seek to identify key papers within a field, to exhaustive systematic reviews (Grant and Booth, 2009). This research follows a systematized review approach (Grant and Booth, 2009) that adopts a pragmatic review of the field, within databases judged to be most appropriate. Unlike a fully systematic review, it does not claim to be a completely exhaustive review of all publications that would include examining from a wide or open-ended period, searching grey literature and using the hand searching of hard copies. Table II outlines the parameters laid out for the review, which was conducted between January and February 2019. Scopus was chosen as the source for the review data as it is currently the largest database of peer-reviewed social and scientific literature. The research reviewed articles in three languages (English, Spanish and German) to access different cultural sources and acknowledge, albeit with "Western" languages, the global nature of museum research (Ritvala *et al.*, 2017). Given the rapid development of recent digital technologies, the review search was focused between 2015 and 2019 to capture current practices. Key research terms and inclusion/exclusion criteria were defined (Table I). The search terms represented four broad search categories, whose interaction reflected the aims of the review.

The initial search produced 294 articles. The abstracts of each of these publications were then screened in accordance with the explicit inclusion and exclusion criteria by two independent reviewers. Table II indicates these criteria.

Where an inclusion/exclusion decision could not be made from the abstract alone, the full article was sourced and screened. The judgements of the two reviewers were then compared and any disagreement discussed. This occurred for three papers. After this second filtering occurred eight articles were selected for final detailed review (Appendix 1). These articles were read in full and a thematic analysis conducted with regard to the goals of the research. In keeping with a systematized research approach, outcome measures and weight of evidence were not considered. The thematic analysis was of descriptive accounts of research within each paper.

Table I The Four categories of search terms

One		*Two*		*Three*		*Four*
Museums	AND	Disability Impairment Cognitive impairment Blind Deaf	AND	Technology	AND	Design

Table II The Focus and parameters of the research literature review

Theme	*Designing technologies to make museums accessible for people with sensory impairment or learning disabilities*
Sub-theme	Usability/Accessibility Design for All
Questions we want the review to address	What it is the nature of participatory research, and to what extent does it occur, within the creation of technologies to facilitate accessible museum experiences?
Date range	2015-2019
Language(s)	English Spanish German
Journal databases	Scopus
Inclusion criteria	For all reviews- papers must be evaluative as well as descriptive- enabling lessons to be drawn from the results or experiences Must involve Museums (in or for a museum) Must involve SI Must involve LD Must involve technology
Exclusion criteria	Doesn't involve Museums Doesn't involve SI/LD Doesn't involve technology
Keyword terms	Disabilities Impairment Cognitive impairment Blind Deaf Technology Museums Design

Findings

Descriptive analysis

The selected eight studies were conducted across 11 countries: the UK, Spain, Korea, Greece, Italy, Poland, Sweden, France, Germany, Belgium and the USA. Five papers (Fonseca *et al.*, 2018; Park *et al.*, 2015; Wilson *et al.*, 2018; Fernandez-Villalobos and Puyuelo, 2018; Yang and Ganz, 2018) did not report the length of the research activities and when they occurred. The type of technologies developed within the studies are outlined in Table III. As Table III illustrates, within this focused sample are a variety of research aims, including creating navigation and spatial awareness tools, location sensitive information, tactile objects and haptic interfaces. These technologies were developed through a range of research and design approaches.

Thematic analysis

Three themes emerged from the thematic analysis.

Accessibility has nuanced meanings

The concept of accessibility is constructed in different ways within the studies, foregrounding different, but complementary, motivations and values. For example, Fonseca's *et al.* (2018) research sees accessibility to culture and assistive learning environments as "fundamental human rights" (p. 941). The purposes of, and audiences for, accessibility projects can also be framed and influenced through political and economic

Table III A summary of the technologies aims and design approaches within the review papers

Article No.	*Technology type*	*Aim of research*	*Design approach*
1	Augmented Reality (AR) for developing a Mobile Augmented Reality (MAR) application	Develop a conceptual model (MARHIME) to provide guidelines to developers for a MAR application to be used in museums by HI visitors	A comprehensive literature review and validation through expert reviews
2	Indoor video-guide. A location-based system to serve 3 D multimedia content for understanding architectural spaces	Proposing a wireless system that offers 3 D virtual content that complements the visit, using a video-guide based on the user's position	The evaluation of the video-guide used in a museum. Mixed-method: quantitative analysis of architecture students' behaviour, and interviews with a sample of students
3	Microcontrollers and sensors	The co-creation of multisensory interactive artworks	Co-researchers working in multisensory, materials and electronics, workshops
4	Haptic telepresence system: robot equipped with haptic display (RGB-D sensor and haptic interface)	To explore art galleries and museums by using a telepresence robot: giving 3 D tactile feedback of the remote environment and controllability	Experimental approach to evaluate the telepresence system performance. Participants' questionnaires to understand users' experiences
5	Phase 1: exploring the use of multilingual devices in European museums. Phase 2: Tobii Pro Glasses 2 for eye-tracking	Evaluating users' attitudes and patterns of engagement	Phase 1: Questionnaires sent to European museums. Phase 2: Measuring reading patterns and behaviour of museum visitors (eye-tracking study)
6	3 D printing replicas	Investigating visitor preference of the physical properties of 3 D replicas	Mixed-methods approach to examine user experience
7	Technologies suggested for heritage sites: 3 D replicas and Augmented Reality	The paper examines study several information and signage projects, to understand and exemplify good practice	Case studies that examine signage resources in different heritage sites
8	Bluetooth Low Energy (BLE) sensors embedded in smartphones	To provide real time spatial awareness for BVI visitors that allows them to navigate independently through public venues	Field tests with users. Questionnaire for user feedback

expectations. These can create attempts to respond to "the needs of the wider community" (Raffi, 2017, p. 36), i.e. those previously disenfranchised from museum culture. Raffi's (2017) research positions the development of universally accessible provision as a way of overcoming social exclusion. She sees this as encompassing not simply the museums physical environment, but also as a transformation of access to diverse cultural contents. These two "levels" of accessibility can be seen in Hollinworth *et al.* (2016), where only the latter seemed possible.

> During tours of the house, visitors in wheelchairs stayed downstairs with a book of photos. The A2H group discussed how we could create an equivalent experience for those not able to get upstairs and mentioned how important it was to be able to touch, smell, and hear the information. (p. 22)

The degree to which an equivalent experience is created is important as researchers would wish disabled users to engage with as authentic an experience as possible. As suggested in the above quote, this can be influenced by the range of modalities being drawn upon. For example, Park's evaluations of haptic, voice and color information (Park *et al.*, 2015) found increasing this range had positive effects in creating a "realistic feeling" through telepresence for participants unable to access the physical location.

In relation to accessing cultural knowledge Raffi (2017) emphasizes the need to consider that "As far as language is concerned, visitors may be unfamiliar with the specific

terminology used in a given field of expertise" (p. 29). This may lead to disengagement with the exhibition, and so the author suggests:

> [. . .] simplifying the text, breaking texts down into logical chunks or using bullet points may have a positive impact on museum visits, enabling visitors to dedicate their time on the exhibition rather than on decoding complex texts. This would make not only the informative elements but also the whole visiting experience more widely enjoyable and accessible (p. 36)

These examples illustrate using technology to help access the physical space, the sensory experience of the exhibits and the mediation of cultural knowledge through text, audiovisual information and symbols. In parallel to visions of creating museums that are universally accessible, which resonates with ideas of universal design, are accounts of accessibility that are personal and made with and for the individual (Fernandez-Villalobos and Puyuelo, 2018). Another complementary aspect of accessibility is the notion of emotional accessibility (Garcia Carrizosa, 2019), which is implied is several studies (Hollinworth *et al.*, 2016; Fernandez-Villalobos and Puyuelo, 2018; Raffi, 2017). For example, within Hollinworth's *et al.* (2016) research, the participatory engagement of users within the research process was personally significant. Feedback from co-researchers indicated that they had

> [. . .] found the opportunity to be involved in research to be an enjoyable and empowering one (p. 36)

This increased their emotional connection, and meaningful engagement, with the museum and its artifacts and cultural activities. Fernandez-Villalobos and Puyuelo (2018) argues that creating accessibility requires

> [. . .] a sensitive perception of the environment and people in their various situations. We must start to deal with this binomial connection in a cautious, respectful way, based on observation and harmony[. . .]. A compatible accessibility criterion must be created, which respects the unique character of each place; namely the search for balance. (p.19)

It can be seen that in creating accessible museum experiences, researchers have emphasized different facets of users experience of accessibility, and for Villalobos, this includes respect for the environment that is being accessed.

Real-life usability

All of the reported technologies demonstrated the potential for enhancing or even transforming the experiences of museum "users" (Sheehy *et al.*, 2019). An emerging theme captured the ways in which the potential benefits of a technology were reflected in terms of everyday usability. For example, in terms of 'flexibility, ease of use and learnability [. . .]" (Baker *et al.*, 2018, pp. 020031-4), which allows technology to be used independently (Yang and Ganz, 2018). However, users must enjoy this use. Therefore, improving their enjoyment may improve the relationship that a user has with the technology and the museum experience. This relationship can limit, or enhance, usability for all (Fonseca's *et al.*, 2018). For example, in one paper, the interface was "[. . .] the most criticized aspect by students with certain difficulties[. . .] [*and also by*] [. . .] the rest of students [. . .]" (Fonseca's *et al.*, 2018). When it comes to design, this suggests that creating effective access to the physical or knowledge components of museums (described in the first theme) needs to consider the preferences of the users. There is a relationship between the users' enjoyment of technologies, their access preferences and the real-life usability of the technology. This aspect of design in facilitating access appears relatively under researched (Fonseca's *et al.*, 2018; Wilson *et al.*, 2018) and emerges as a key area in improving real life usability (Wilson *et al.*, 2018). The attractiveness (enjoyment, access preferences and usability) of a technology drives its everyday usability, and it seems reasonable to argue that this attractiveness needs to represent benefits for both the primary users and museum

staff. While the technological benefits of a technology are often stated in the review papers, evidence for attractiveness, and hence real-life usability, appears to be lacking overall.

The nature of participation and participants

A theme that emerged across the studies captured the different ways in which participants were involved, or not, with the research. This theme also encompasses the degree to which heritage site and museum staff and organizations are involved within the research and development of the technologies. This aspect of participation appears to be relatively limited and may reflect the sample papers' focus towards developing new technologies, rather than evaluating *in situ* implementations with museum partners. Consequently, museums appear mainly as an inert space where research occurs rather than as site of active research partners. The exception to this is Hollinworth *et al.* (2016), where museum staff, researchers, potential end users and volunteers were involved in the co-creation of accessible artefacts. In two other studies museums staff returned questionnaire (Raffi, 2017) and assisted in data collection (Wilson *et al.*, 2018).

The involvement of participants [i.e. end users of technologies] with sensory impairment and/or learning disabilities in the research process is illustrated in Table III. This shows that end users were involved in four research studies (Fonseca *et al.*, 2018; Hollinworth *et al.*, 2016; Park *et al.*, 2015; Yang and Ganz, 2018), albeit as a small minority in (Fonseca *et al.*, 2018) and (Park *et al.*, 2015). No end users involved Baker's *et al.* (2018) theoretical review paper or Studies 5 and 6 (Table IV).

The use of non-disabled "proxies" is relatively common and has been criticized for producing weak understanding of users' real-life experiences (Silverman *et al.*, 2015). This occurred in only two studies in the reviewed sample. In Wilson *et al.* (2018) and Fernandez-Villalobos and Puyuelo (2018), the research addresses access for a general population.

The nature of participants' involvement within the research can be seen as varying across a continuum. At one end of this continuum would be the participants contributing as co-researchers (Hollinworth *et al.*, 2016). Next and most common was participants giving feedback to researchers that might inform improving access (Fonseca *et al.*, 2018; Park *et al.*, 2015; Wilson *et al.*, 2018). Then, participants whose engagement with artifacts was monitored and analyzed by researchers, followed by the other end; a researcher only analysis of heritage sites (Fernandez-Villalobos and Puyuelo, 2018) and an expert review approach (Baker *et al.*, 2018) in which domain specialists validate particular elements of the technology. This continuum reflects the degree of active involvement of participants in influencing the research that is being undertaken.

Table IV Involvement of types of disabled users within the studies

Article No.	*End user research participants*	*Other participants*
1	People with hearing-impaired (HI). None involved	N/A
2	4 students with attention deficit hyperactivity (ADHD)	32 architecture students in total, [4 of whom identified as having ADHD]
3	People with learning disabilities (number of participants unknown)	workshop participants: artists, technologists, multimedia practitioners, educators, museum professionals and volunteers
4	5 visually impaired users (2 low-vision; 3 blind)	26 participants in total: 21 were sighted
5	People with sensory impairments. None involved	16 museum visitors
6	Diverse categories of the population	140 museum visitors
7	None specified	Researcher analysis of sites
8	6 blind or visually impaired participants	N/A

Discussion

This review set out to explore participation in the context of designing technologies to support museum accessibility. An original finding has been the emergence of an expanded and nuanced view of the concept of accessibility. The studies, variously, reflect a construction of accessibility that is values driven and can operate a different level of implementation: physical, social, cognitive and emotional, and which respects both the person and the environment they are seeking to access.

The values underpinning accessibility design are important. Technology becomes able to enhance the modalities which mediate users experience. This helps create a more authentic experience, potentially bringing the user closer to previously inaccessible artifacts and sites. However, it also risks creating an alternative situation in which some disabled users are confined to virtually mediated experiences away from the physical heritage site and indeed other visitors (Sheehy *et al.*, 2014). The values that drive accessibility design will be important in negotiating this tension and there is evidence that some researchers are positioned to do this (Raffi, 2017; Fonseca *et al.*, 2018; Hollinworth *et al.*, 2016).

Typically, the notion of participation has focused on the involvement of disabled people within the research process and this review has highlighted a continuum of practices that exist in this respect (Rix *et al.*, 2019). This continuum reflects the degree of active involvement of participants in influencing the research that is being undertaken. It is likely that this continuum also reflects the stage of development and complexity of the technology that is being designed. Both these factors impact upon the ways in which end user participants might engage with the research process. Therefore, a simple view of a participation continuum may be misguided. It is however clear that disabled people, for whom access technologies are being designed, should feature more strongly within the research than this review sample indicates. In particular the use of "proxies" for disabled participants is problematic, denying the user groups a voice in the process and distorting research conclusions (Silverman *et al.*, 2015). This practice may reflect a simple view of accessibility, focused on the technology alone, rather than one that is shaped by the broader purposes of the research and design process. This may also partly explain why the research participants were commonly identified in terms of a single disability "label," matching the technology to a specific disability category. Only one study (Wilson *et al.*, 2018) took a broader view that considered access for all, more akin to a universal design perspective.

An original notion of participation has emerged from this review. It includes the participation and goals of disabled people but has expanded the concept to encompass museum personnel and indeed the physical (Fernandez-Villalobos and Puyuelo, 2018) and social (Fonseca *et al.*, 2018; Raffi, 2017) spaces of the museums and heritage sites themselves. This constructs a broad of participation, with different aspects being reflected across the review's research papers.

Conclusion

This research review indicates that a range of innovative technologies are being designed to facilitate accessibility for museum visitors. Although this is a relatively small sample of recent research, it includes haptic telepresence robots, multisensory artworks, 3D multimedia, multilingual devices and augmented reality applications. These new technologies have the potential to transform the museum experiences for people with sensory impairment and/or learning disabilities.

The notion of accessibility that has emerged is of a multi-layered concept, underpinned by values which see accessibility as a fundamental human right and way of delivering important social goals. While the studies reviewed could all be seen as working toward this end, the means of achieving this, in relation to research participation, are more varied.

Participants were typically involved in giving feedback to researchers rather than being involved as co-researchers, and although the stage of development or complexity of a project may mitigate against a co-researcher approach in some cases, the use of non-disabled proxies implies that more involvement is possible.

Future research that seeks to design museum technologies for people with sensory and intellectual impairments will need to become more attuned to issues of inclusion and participation. This will impact on *who* the researchers are, i.e. the composition of the research team, and *how* disabled people contribute to the research process. It will be important therefore to research the processes that might enable these changes, building on the relatively few examples that currently exist such as the ARCHES Horizon 2020 project (Garcia Carrizosa *et al.*, 2019).

The research identifies a lack of involvement with museum staff, i.e. those who would be supporting the implementation of new technologies in the museum and providing accessibility support for visitors. If the design process is to be more inclusive and produce sustainable change within museums, then the possibility of their deeper engagement should be examined further. The attractiveness (as defined previously of the technologies to both end users and supporters) is vital if the technology is to have a real-life usability and have a meaningful impact in peoples' lives. Having a notion of participation in research which is broad is likely to support the design of such technologies.

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